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(54) RING TOPOLOGICAL STRUCTURE OF PET IMAGING SYSTEM AND IMPLEMENTATION METHOD THEREOF

(57) The present invention relates to a ring topological structure of a PET imaging system and an implementation method thereof, which relate to the technical field of basic topology of PET, PET/CT and PET/MR medical imaging systems. Event conformation judging of a PET system is completed by a series of distributed conformation modules, the conformation modules are serially connected into a ring structure, and each conformation module is a node module on a link; and at least one node module is filtered out from the ring structure to take out a conforming event. Calculation volume and IO load of a conformation processing unit are greatly reduced, switching between production of a simple system and production of a complex system is implemented, and development and research efficiency is greatly improved. Production of the PET system presents a block building effect and three-ring, four-ring, five-ring and six-ring systems can be conveniently produced. Meantime, switching between high and low resolution and production switching of a small system of a small animal and a large system of a human body are implemented by increasing or reducing node quantity and changing size of crystal in a detector.

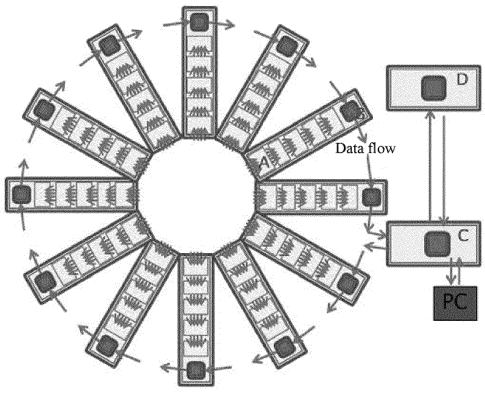

FIG. 1

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Description

BACKGROUND

Technical Field

[0001] The present invention relates to a basic topological structure of a PET, PET/CT, and PET/MR medical imaging system, and an implementation method of the basic structure.

Related Art

[0002] PET is an instrument for nuclear medical functional imaging, which can be used for fast diagnosis of a cancer cell mass, particularly early-stage cancers, and is a good tool for diagnosis and treatment of tumors, cardiovascular diseases and neurologic diseases and is thus clinically used rapidly. As a large-scale radioactive surgery system, the PET has ten thousands or hundred thousands of measuring detector units for imaging. By reducing the quantity of designed detector channels to thousands, an imaging effect is achieved: in several minutes, millions of conforming events are at least obtained, and only a distributed collecting mode can be adopted to judge and discard millions of non-conforming single events.

[0003] A star structure is a collecting mode usually adopted by the current PET system. After being amplified and formed, the signal of each detector is converted to digital information by independent ADs, data of a plurality of ADs are converged into one concentrated processing unit (front-end) for processing so as to judge useful full-energy peak events, and the position of rays at the minimal imaging unit is analyzed; all processing unit events are converged into one central processing unit, namely the conformation processing unit, and conforming events are judged and output in a concentrated manner.

[0004] The star topological structure is a natural logic result, and distributed information is processed and output in a concentrated manner. But, when design of such a structure is completed, an imaging system is unique and fixed, and is a system which cannot be changed on hardware. Branch quantity for receiving information at the central processing unit and branch information capacity, namely the quantity of detector units for processing is fixed, and any small modification to the hardware results in the brand new design of the whole PET system. When development of the high performance PET system faces the high hardware IO, the central processing unit also faces challenges of great processing capacity and data bandwidth.

SUMMARY

[0005] The present invention aims to provide an implementation method of a topological structure of a PET imaging system, which can reduce processing workload of conformation modules, increase IO channel quantity of hardware and randomly increase or reduce processing capacity of ray detectors of the system, so as to conveniently produce three-ring, four-ring, five-ring and six-ring systems.

[0006] Event conformation judging of the PET system is completed by a series of distributed conformation modules, the conformation modules are serially connected into a ring structure, and each conformation module is a node module on a link; and at least one node module is filtered out from the ring structure to take out a conforming event.

[0007] A specific method includes: electronic signals of a plurality of groups of detectors are converged to one event processing module, forming, digitalization and digital analysis of signals are completed at the event processing module, and a full energy peak event is selected; information of a plurality of event processing modules is output and converged to one node module, and the event conformation judging is performed in the node module; a complex system forms star branches by adopting a plurality of event processing modules and the conformation modules, and respective branched conformation modules are cascaded to form a ring star structure, and functions of the processing modules and functions of the conformation modules in a simple imaging system are combined together to form the node modules, which are cascaded to form a single ring structure.

[0008] A topological structure of the present invention includes event processing modules used for receiving and processing signals from a plurality of ray detectors, an event conformation detection node module for receiving events from the plurality of event processing modules, and at least one conforming event filter node module;

each of the node modules and the filter node module are sequentially serially connected by a bus or point-to-point data transmission to form a closed ring structure, and data information is generated on the detectors, is firstly converged to the event processing modules, is further converged to the node modules to enter the ring structure, and circularly flows in the ring structure.

each node module caches the information converged on the node module for conformation detection, and directly issues the information of the node module to the next node module, so the information of a node flows in the ring structure;

each node module judges and deletes information from the node module or the outdated information from the last node module, forbids the continuous transmitting of the deleted information and balances and reduces data volume continuously entering the ring;

each node module performs time judgment on the event information from the last node module and event information of the node module, judges two events simultaneously occurring in a conformation time window as a conforming event and then marks the information of the conforming event;

each node module sends the information of the conform-

ing event or the information of an non-outdated single event from the last node module to the next node module, so the conforming event is transmitted to a conforming event filter node and the single event has bigger chance to be subject to conformation judging together with the events on more nodes; and

the filter node detects the information of a conformation mark event, forbids the detected information of the conformation mark event from continuously transmitting to the next node module, and sends the information of the conforming event to a computer for data collection.

[0009] The work principle of the present invention is as follows: signals of respective ray detectors are converged to the event processing modules (front-end function modules) through AD conversion, and full-energy peak judgment and analysis on a detected crystal position are realized after processing of the event processing modules; event information of a plurality of event processing modules are converged to one conformation node module, a signal transmission loop is formed by serial connection of lots of node modules, and conformation judging of events is finished on the loop; the nodes send conformed new information to the next node module, namely, the conformation data are circulated in the loop till reaching at the filter node module having detected conformation mark event information, and transmitting the detected conformation mark event information to a connected calculation center, the filtered conforming event information is further transmitted to a detection and control function module of the PET system under control of the calculation center; events screened by the event processing modules are single events, a copy is cached when the single events are converged to the nodes and is kept till conformation is detected or outdating is detected, and the other copy is injected into the loop for circulation till conformation is detected or outdating is detected.

[0010] The present invention realizes a loop structure of a central processing unit, concentrated tasks are distributed to respective node modules, a hardware structure and a software (FPGA) structure of each node are same in function, tasks become simple and effective, IO quantity of each unit is reduced, use efficiency of a data transmission link is improved, but total IO quantity of the system is increased and a processing capacity is greatly improved. More importantly, according to the PET system with such a ring structure, by increasing and reducing node quantity and node processing quantity, block building type production of a PET system is achieved without changing hardware electronics and FPGA program in the hardware, namely without changing system design, and production of clinical and research PET from high class to low class is achieved according to user needs. By using this structure, calculation volume and IO load of the conformation processing units are greatly reduced, switching between the production of a simple system and the production of a complex system is implemented, and research and development efficiency is greatly improved. The production of the PET system presents a block building effect, three-ring, four-ring, five-ring and six-ring systems can be conveniently produced, switching between high and low resolution and production switching of a small system of a small animal and a large system of a human body is implementing by increasing or reducing node quantity and changing size of crystal in a detector.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a ring plus star topological structure and data flow schematic diagram when the present invention is used in a large system of a human body; and

FIG. 2 is a ring topological structure and data flow schematic diagram when the present invention is used in a small system of a small animal.

DETAILED DESCRIPTION

[0012] As shown in FIG. 1, A are pluggable event processing modules (front-end function modules) for receiving and processing signals form a plurality of ray detectors, B are conformation node modules, C is a filter node module of a conforming event in the ring structure, and D is a detection and control function module of the PET system. PC is a data collection computer.

[0013] Respective processing units A can be (but not limited to) a case pluggable manner, respective node modules B can be arranged on a motherboard of a case, the node modules B are linked in a variable socket manner, and the modules B can automatically identify a plugboard of the case.

[0014] Respective node modules B and the filter node module C are sequentially serially connected by a bus or point-to-point data transmission to form a closed ring structure, that is to say, respective cases are serially connected by a data line.

[0015] Each node module B caches information of the node module for conformation detection, and directly issues the information of the node module to the next node module.

[0016] Each node module judges and deletes the information from the node module or outdated information from the last node module and forbids the continuous transmitting of the deleted information.

[0017] Each node module performs time judgment on the information from the last node module and the information of the node module, judges a conforming event in a conformation time window and then marks the information of the conforming event.

[0018] Each node module sends the information of the conforming event or the information of a non-outdated single event from the last node module to the next node module;

[0019] The filter node module C detects the information

of a conformation mark event, sends the information of the detected conforming event to a connected calculation center PC, and forbids the detected information of the conformation mark event from continuously transmitting to the next node module.

[0020] Under control of the calculation center PC, the information of the detected conformation mark event is transmitted to the detection and control function module D of the PET system.

[0021] All above function modules and node modules generally refer to FPGAs of hardware so as to obtain a high speed timely processing capacity.

[0022] As shown in FIG. 2, the shown ring structure is same as the star plus ring structure as shown in FIG. 1, respective node modules B and the filter node module C are sequentially serially connected by a bus or point-to-point data transmission to form a closed ring structure, respective node modules and the filter node module have the completely same event conformation judgment and filter and event information transmittance and outdating deleting functions. The system is simple, so quantity of the detectors is small, signals of the detectors are directly connected to the node modules, which finish the function of the last level of event analysis modules, thus simplifying the system structure.

Claims

1. An implementation method of a ring topological structure of a PET imaging system, wherein event conformation judging of a PET system is completed by a series of distributed conformation modules, the conformation modules are serially connected into a ring structure, and each conformation module is a node module on a link; and at least one node module is filtered out from the ring structure to take out a conforming event.

2. The method according to claim 1, wherein electronic signals of a plurality of groups of detectors are converged to one event processing module, forming, digitalization and digital analysis of a signal are completed at the event processing module, and a full energy peak event is selected; information of a plurality of event processing modules is output and converged to one node module, and the event conformation judging is performed in the node module; a complex system forms star branches by adopting a plurality of event processing modules and the conformation modules, and respective branched conformation modules are cascaded to form a ring plus star structure, functions of the processing modules and functions of the conformation modules in a simple imaging system are combined together to form the node modules, which are cascaded to form a single ring structure.

3. A ring topological structure of a PET imaging system, comprising: event processing modules for receiving and processing signals from a plurality of ray detectors, an event conformation detection node module for receiving events from the plurality of event processing modules, and at least one conforming event filter node module;
each of the node modules and the filter node module are sequentially serially connected by a bus or point-to-point data transmission to form a closed ring structure;
each node module caches information of the node module for a function module of conformation detection, and directly issues the information of the node module to the next node module;
each node module judges and deletes the information from the node module or outdated information from the last node module and forbids the continuous transmitting of the deleted information;
each node module performs time judgment on the information from the last node module and the information of the node module, judges a conforming event in a conformation time window and then marks the information of the conforming event;
each node module sends the information of the conforming event or the information of non-outdated single event from the last node module to the next node module; and
the filter node module detects the information of a conformation mark event, forbids the detected information of the conformation mark event from continuously transmitting to the next node module, and sends the information of the detected conforming event to a computer for data collection.

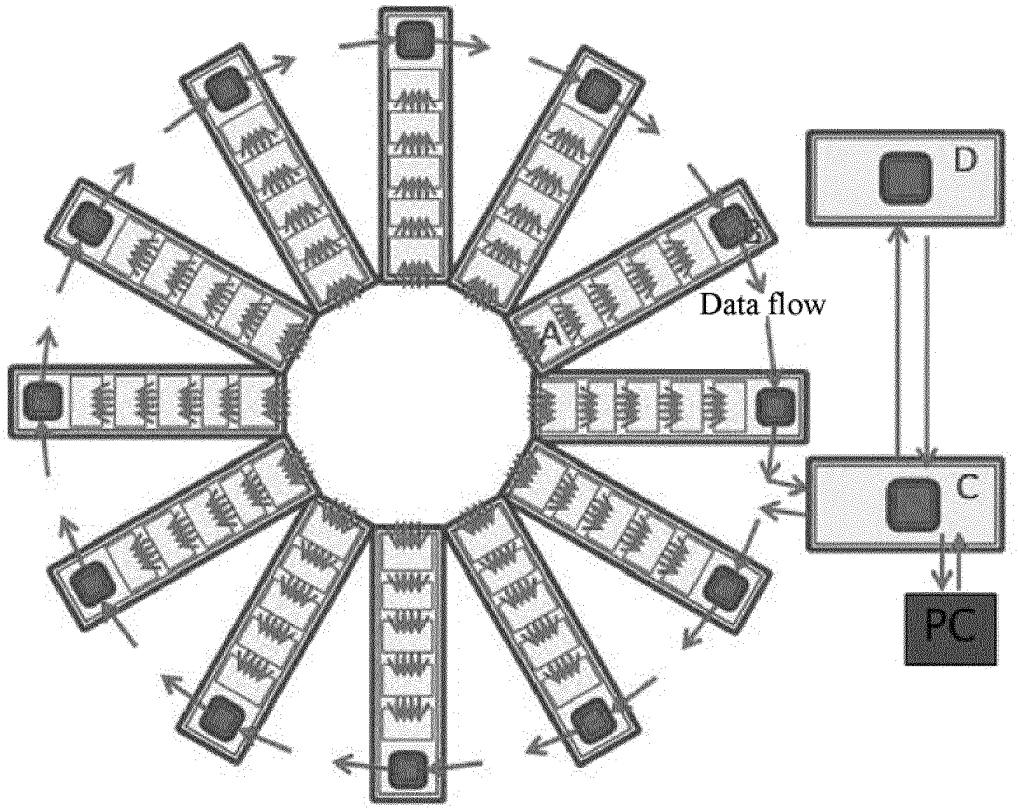

FIG. 1

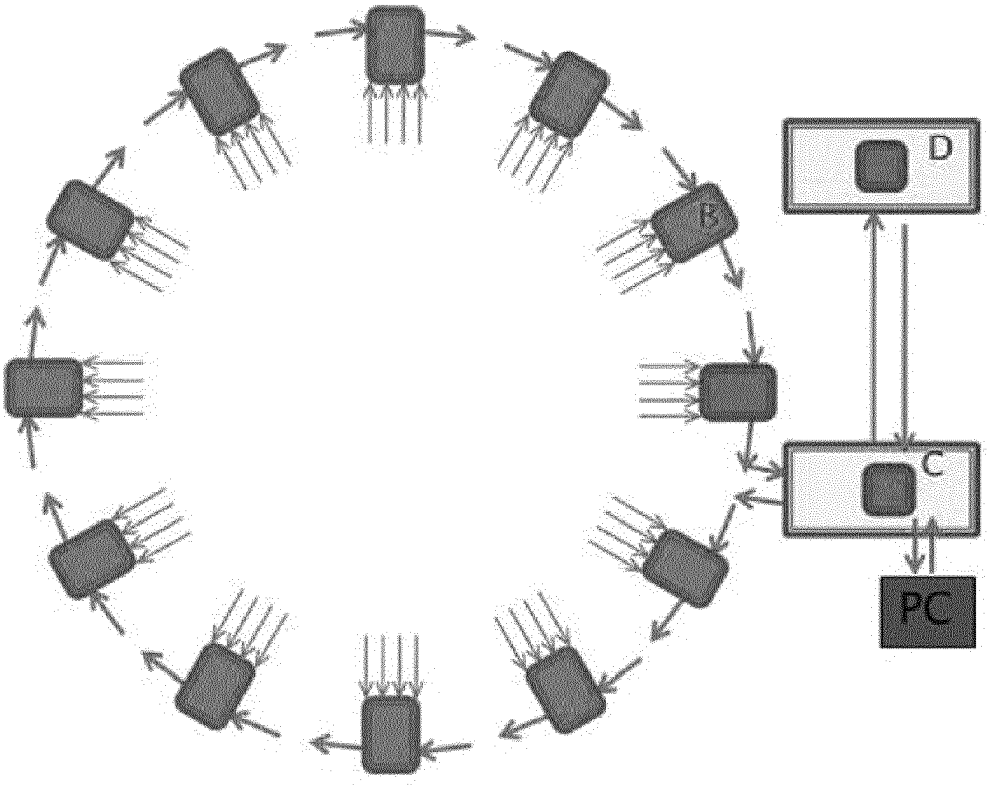

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/081183

A. CLASSIFICATION OF SUBJECT MATTER

A61B 6/03 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS, CNTXT, CNKI, VEN, WOTXT, EPTXT, USTXT, JPTXT: arc, continuation, PET, positron, coincidence, topology+, circle, annulus, ring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 101855564 A (ROYAL DUTCH PHILIPS ELECTRONICS LTD.), 06 October 2010 (06.10.2010), description, paragraphs [0023]-[0050], and figures 1-3	1-3
A	CN 102302372 A (SINOWAYS MEDICAL TECHNOLOGY CO., LTD.), 04 January 2012 (04.01.2012), the whole document	1-3
A	CN 102631212 A (INSTITUTE OF HIGH ENERGY PHYSICS, CHINESE ACADEMY OF SCIENCES), 15 August 2012 (15.08.2012), the whole document	1-3
A	WO 2010048626 A2 (UNIVERSITY OF WASHINGTON et al.), 29 April 2010 (29.04.2010), the whole document	1-3
A	US 2004195512 A1 (CTOSETTO, D.B.), 07 October 2004 (07.10.2004), the whole document	1-3

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2013 (29.11.2013)	**12 December 2013 (12.12.2013)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **ZHANG, Qingnan** Telephone No.: (86-10) **62085610**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/081183

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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Form PCT/ISA/210 (patent family annex) (July 2009)